

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
7 September 2001 (07.09.2001)

PCT

(10) International Publication Number  
**WO 01/64444 A1**

(51) International Patent Classification:  
2/155

B41J 2/145,

(74) Agent: SILVERBROOK, Kia; Silverbrook Research Pty Ltd, 393 Darling Street, Balmain, New South Wales 2041 (AU).

(21) International Application Number: PCT/AU01/00216

(22) International Filing Date: 2 March 2001 (02.03.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:  
PQ 5959 2 March 2000 (02.03.2000) AU

(71) Applicant (for all designated States except US): SILVERBROOK RESEARCH PTY LTD [AU/AU]; 393 Darling Street, Balmain, New South Wales 2041 (AU).

(81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:

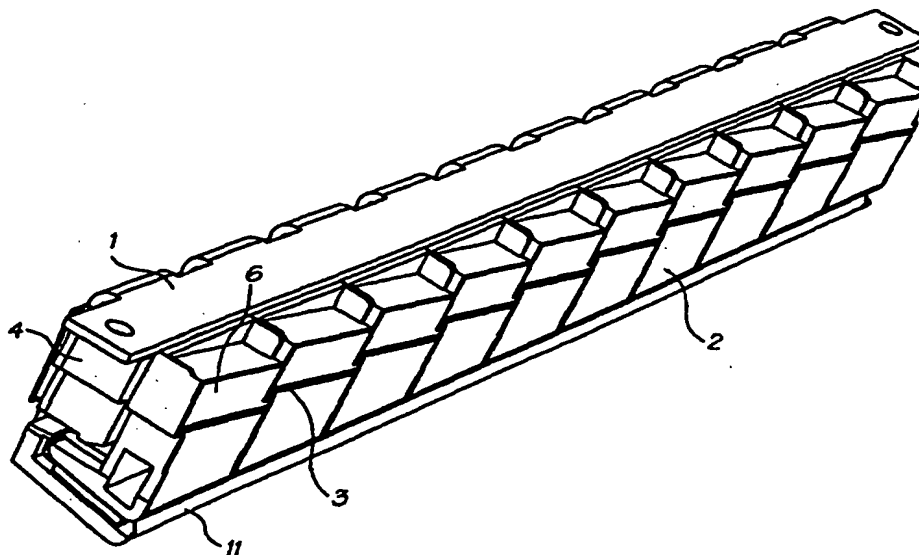
— with international search report

(72) Inventor; and

(75) Inventor/Applicant (for US only): SILVERBROOK, Kia [AU/AU]; Silverbrook Research Pty Ltd, 393 Darling Street, Balmain, New South Wales 2041 (AU).

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: OVERLAPPING PRINthead MODULE ARRAY CONFIGURATION



(57) Abstract: A modular pagewidth printhead for a digital ink jet printer having a metal chassis (1) where modules (2) are arranged in an overlapping configuration to preserve continuity between the printing from adjacent replaceable modules (2). The printhead has an ink reservoir (4), a flexible PCB (10) and busbar (11). The printhead chips (3) such as MEMJET on each module (2) receive print data from TAB films (6). The TAB films (6) extend from the same side of each of the MEMJET chips (3) to allow for a relatively compact printhead design. The chips (3) are configured so that predominately all of the chips (3) in the array have, at most, one end obscured by the end of an adjacent chip (3). The configuration includes overlapping and inclining the printheads with respect to the support beam. This reduces the amount that the TAB films (6) need to narrow or "neck" in order to avoid the obscuring adjacent end.

WO 01/64444 A1

BEST AVAILABLE COPY

**THIS PAGE BLANK (USPTO)**

**OVERLAPPING PRINthead MODULE ARRAY CONFIGURATION****Field of the Invention.**

The invention relates broadly to digital inkjet printers and in particular to digital  
5 ink jet printers configured to print the entire width of a page simultaneously.

**Co-Pending Applications.**

Various methods, systems and apparatus relating to the present invention  
are disclosed in the following co-pending applications filed by the applicant or assignee  
of the present invention on 24 May 2000:

10	PCT/AU00/00578	PCT/AU00/00579	PCT/AU00/00581	PCT/AU00/00580
	PCT/AU00/00582	PCT/AU00/00587	PCT/AU00/00588	PCT/AU00/00589
	PCT/AU00/00583	PCT/AU00/00593	PCT/AU00/00590	PCT/AU00/00591
	PCT/AU00/00592	PCT/AU00/00584	PCT/AU00/00585	PCT/AU00/00586
	PCT/AU00/00594	PCT/AU00/00595	PCT/AU00/00596	PCT/AU00/00597
15	PCT/AU00/00598	PCT/AU00/00516	PCT/AU00/00517	PCT/AU00/00511

The disclosures of these co-pending applications are incorporated herein by cross-  
reference. Also incorporated by cross-reference, is the disclosure of a co-filed PCT  
application, PCT/AU01/00217 (deriving priority from Australian Provisional Patent  
20 Application No. PQ5957).

**Background of the Invention.**

Traditionally, inkjet printers have used a printing head that traverses back and forth  
across the width of a page as it prints. Recently, it has been possible to form printheads  
25 that extend the entire width of the page so that the printhead can remain stationary as the  
page is moved past it. As pagewidth printheads do not move back and forth across the  
page, much higher printing speeds are possible.

Pagewidth printheads are typically micro electro mechanical systems (MEMS)  
devices that are manufactured in a manner similar to silicon computer chips. In this  
30 process, the ink nozzles and ejector mechanisms are formed in a series of etching and  
deposition procedures on silicon wafers.

As an industry standard, the silicon wafers are produced in 6 or 8 inch diameter disks. Consequently only a small strip across the diameter of each wafer can be used to produce printing chips of sufficient width for pagewidth printing. As a large part of these wafers are essentially wasted, the production costs of pagewidth printhead chips  
5 are relatively high.

The costs are further increased because the chip defect rate is also relatively high. Faults will inevitably occur during silicon chip manufacture and some level of attrition is always present. A single fault will render an entire pagewidth chip defective, as is the case with any silicon chip production. However, because the pagewidth chip is larger  
10 than regular chips, there is a higher probability that any particular pagewidth chip will be defective thereby raising the defect rate as a whole in comparison to regular silicon chip production.

To address this, the pagewidth printhead may be formed from a series of separate printhead modules. Using a number of adjacent printhead modules permits full  
15 pagewidth printing while allowing a much higher utilization of the silicon wafer. This lowers the printhead chip defect rate because a fault will cause a relatively smaller printhead chip to be rejected rather than a full pagewidth chip. This in turn translates to lower production costs.

Each printhead chip carries an array of nozzles which have mechanical structures  
20 with sub-micron thickness. The nozzle assemblies use thermal bend actuators that can rapidly eject ink droplets sized in the Pico litre ( $\times 10^{-12}$  litre) range.

The microscopic scale of these structures causes problems when butting a series of printhead modules end to end in order to form a pagewidth printhead. Microscopic irregularities on the end surfaces of each chip prevent them from perfectly abutting the  
25 end surface on an adjacent chip. This causes the spacing between the end nozzles of two adjacent printhead chips to be different from adjacent nozzles on a single printhead chip. The gaps between adjacent printhead chips can lower the resultant print quality.

To eliminate the gaps, some modular pagewidth printheads use two adjacent lines of regularly spaced printhead modules. The lines are out of register with each other and  
30 the ends of a printhead module in one line overlaps with the ends of two adjacent modules in the other line. This removes the gaps from the resultant printing but also provides redundant nozzles in the areas of overlap. The print data to the overlapping

nozzles is allocated between the adjacent chips so that these areas are not printed twice which would otherwise have adverse affects on the print quality.

A digital controller is connected to each of the printhead module chips via a TAB (tape automated bond) film. The TAB film is substantially the same width as the chip  
5 and this causes difficulties when mounting the chips to a support structure within the printer. It is preferable that the TAB films for each chip extend from the same side as this permits a more compact and elegant printhead design. However, this arrangement requires the TAB films from each of the chips in one of the lines to narrow or 'neck' in order to fit past the restriction caused by the overlapping ends of the adjacent chips in the  
10 other line. Producing and installing TAB films that narrow down enough is complex and difficult. To avoid this, the TAB films can extend from one side of the chips in one line and from the opposite side of the chips in the other line. However, as discussed above this gives the overall printhead greater bulk that can complicate the paper path through the printer as well as hamper capping the printheads when the printer is not in use.

#### 15 **Summary of the Invention.**

Accordingly, the present invention provides a modular printhead for a inkjet printer, the modular printhead including:

- a support frame;

- a plurality of printhead modules mounted to the support frame, each module  
20 having an elongate array of ink nozzles extending substantially linearly across the width of the module such that there is overlap between the elongate arrays of adjacent modules with respect to the direction of paper movement; wherein,

- the modules are arranged such that a first side of each of the nozzle arrays faces toward a first side of the support frame; such that,

- 25 the respective first sides of predominantly all of the nozzle arrays have at most one end portion obscured from the first side of the support frame by the nozzle array of an adjacent module.

Preferably, the respective first sides of each of the nozzle arrays have at most one end portion obscured from the first side of the support frame by the nozzle array of an  
30 adjacent module.

By inclining the printhead chips with respect to the support beam and configuring them to overlap with respect the to paper direction, the TAB films for each chip can

extend from the same side. This allows the printhead design to remain relatively compact while avoiding the need to significantly narrow or 'neck' most if not all the TAB films.

Preferably, the modules are mounted to the support frame along a substantially  
5 straight mounting line such that each of the elongate arrays extends in a direction inclined to the mounting line of the modules. In a further preferred form, the mounting line is normal to the paper direction.

Preferably, the printhead is digitally controlled such that print data sent to the overlapping portions of adjacent modules is shared between the ink nozzles of the  
10 adjacent modules to avoid double printing of the same data.

In a particularly preferred form, the digital controller starts to place print data with the nozzles in an adjacent module at the one edge of the overlapping portion, and ramps up the data directed to the nozzles of the adjacent module stochastically until all the print data is directed to the adjacent module at the opposing edge of the overlapping  
15 portion.

Preferably, the printhead is a pagewidth printhead.

In a further preferred form, the printhead modules are adapted to be individually removed and replaced. To achieve this the printhead modules may be conveniently adapted for snap-locking engagement with the support frame.

It will be appreciated that the adjacent positioning of a number of small modular  
20 printheads permits full pagewidth printing while allowing a much higher utilization of the silicon wafer. Furthermore, the defect rate is effectively lower because a single fault will mean that a relatively smaller printhead chip will be rejected rather than a large full pagewidth printhead chip. Accordingly, the production costs per chip are significantly  
25 reduced.

By providing each modular printhead with snap-lock formations, it is convenient to individually remove and replace defective modules.

#### **Brief Description of the Drawings.**

A preferred embodiment of the present invention will now be described by way of  
30 example only with reference to the accompanying drawings in which:

Figure 1 schematically shows a series of printhead modules abutting end to end to form a pagewidth printhead;

Figure 2 shows an enlarged view of the junction between two adjacent printhead modules shown in Figure 1;

Figure 3 schematically shows the printhead modules configured in an overlapping relationship with TAB films extending from both sides of the printhead chips;

5        Figure 4 schematically shows the printhead modules configured in an overlapping relationship with TAB films extending from only one side of the printhead chips such that every second TAB film is narrowed;

Figure 5a schematically shows the printhead modules configured in an overlapping relationship in accordance with the present invention;

10       Figure 5b schematically shows an alternative configuration of the printhead modules in an overlapping relationship in accordance with the present invention;

Figure 5c schematically shows another alternative configuration of the printhead modules in an overlapping relationship in accordance with the present invention;

15       Figure 5d schematically shows one more configuration of the printhead modules in an overlapping relationship in accordance with the present invention;

Figure 6 schematically shows a single printhead chip in relation to the paper path;

Figure 7 schematically shows the overlap region between two adjacent modules;

Figure 8 is a perspective view showing the underside of a modular printhead according to the present invention;

20       Figure 9 shows a rear view of the modular printhead at Figure 8;

Figure 10 is a plan view of the modular printhead shown in Figure 8;

Figure 11 is a front view of the modular printhead shown in Figure 8;

Figure 12 is an underneath view of the modular printhead shown in Figure 8;

Figure 13 is a left end view of the modular printhead shown in Figure 8;

25       Figure 14 is a perspective view of the underside of a modular printhead with several of the printhead modules removed;

Figure 15 shows an exploded perspective view of a printhead module;

Figure 16 shows an underside view of a printhead module;

Figure 17 shows an end view of a printhead module; and

30       Figure 18 shows a cross-sectional view of the modular printhead shown in Figure 8.

**Detailed Description of the Preferred Embodiment.**

Referring to Figures 1 to 4, prior art arrangements for modular pagewidth printheads are shown. In Figure 1, the printhead chips (3) of each module (not shown) are simply abutted end to end across the printhead support beam (not shown). As shown in the enlarged view of Figure 2, the ink nozzles are laterally spaced at a distance  $x$  along the chip. However, the microscopic irregularities in the ends of the chips (3) are enough to alter the normal spacing between the nozzles such that the end nozzles on adjacent chips are laterally spaced by a greater distance  $y$ . This adversely affects the print quality and can result in a blank line or void in the resultant printing.

Figure 3 shows the printhead chips (3) arranged in an overlapping configuration to avoid any gaps between the printing from adjacent modules. The digital controller (not shown) shares the print data amongst the overlapping nozzles of the adjacent printhead chips so that print data is not printed twice. The TAB films (6) from each chip (3) extend from opposing sides of each adjacent chip, in order to avoid having to narrow the TAB film (6) to every second chip (3) as shown in Figure 4. However, with the TAB films (6) extending from both sides of the chip array, the printhead becomes much wider which complicates the printer design, and in particular the paper path.

Referring to Figures 5a to 5d, various suitable configurations of the chip array are shown. To be suitable, the array must allow the TAB film to extend from the same side of each chip with little or no narrowing required while maintaining the chips in an overlapping relationship with respect to the paper direction. This is achieved by ensuring that the TAB film side of each chip is only obscured at one end, if at all. For illustrative purposes, the obscured areas of the chips are shaded.

The arrangement shown in Figure 5a offers the best configuration in terms of compact printhead design as well as overall printer design. The printhead chips (3) are inclined relative to the support beam or at least the line along which the modules (2) are mounted. This allows the printhead chips (3) to overlap with respect to the paper path while the TAB films (6) extend from the same side of each chip without being significantly narrowed. The support beam extends normal to the paper direction so that the printing occurs over a minimal length of the paper path so that the overall dimensions of the printer are reduced.

The present invention will now be described with particular reference to the Applicant's MEMJET™ technology, various aspects of which are described in detail in



the cross referenced documents. It will be appreciated that MEMJET™ is only one embodiment of the invention and used here for the purposes of illustration only. It is not to be construed as restrictive or limiting in any way on the extent of the broad inventive concept.

5           A MEMJET™ printhead is composed of a number of identical printhead modules (2) described in greater detail below. Throughout the description and the cross references the array of ink ejecting nozzles on each module has been variously referred to as a 'printhead chip', 'chip' or 'segment'. However, from a fair reading of the whole specification in the context of the cross references, the skilled artisan will readily  
10 appreciate that these integers are essentially the same.

          A MEMJET™ printhead is a drop-on-demand 1600 dpi inkjet printer that produces bi-level dots in up to 6 colors to produce a printed page of a particular width. Since the printhead prints dots at 1600 dpi, each dot is approximately 22.5µm in diameter, and the dots are spaced 15.875µm apart. Because the printing is bi-level, the  
15 input image is typically dithered or error-diffused for best results.

          Typically a MEMJET™ printhead for a particular application is page-width. This enables the printhead to be stationary and allows the paper to move past the printhead. Figure 8 illustrates a typical configuration. 21mm printhead modules are placed together after manufacture to produce a printhead of the desired length (for  
20 example 15 modules can be combined to form a 12-inch printhead), with overlap as desired to allow for smooth transitions between modules. The modules are joined together by being placed on an angle such that the printhead chips (3) overlap each other, as shown in Figure 5. The exact angle will depend on the width of the MEMJET™ module and the amount of overlap desired, but the vertical height is in the order of 1mm,  
25 which equates to 64 dot lines at 1600 dpi.

          Each chip has two rows of nozzles for each color, an odd row and an even row. If both rows of cyan nozzles were to fire simultaneously, the ink fired would end up on different physical lines of the paper: the odd dots would end up on one line, and the even dots would end up on another. Likewise, the dots printed by the magenta  
30 nozzles would end up on a completely different set of two dot lines. The physical

distances between nozzles is therefore of critical importance in terms of ensuring that the combination of colored inks fired by the different nozzles ends up in the correct dot position on the page as the paper passes under the printhead.

The distance between two rows of the same color is  $32\mu\text{m}$ , or 2 dot rows.

- 5 This means that odd and even dots of the same color are printed two dot rows apart. The distance between rows of one color and the next color is  $128\mu\text{m}$ , or 8 dot lines apart. If nozzles for one color's dot line are fired at time T, then nozzles for the corresponding dots in the next color must be fired at time T + 8 dot-lines. We can generalize the relationships between corresponding nozzles from different rows by defining two
- 10 variables:

$D_1$  = distance between the same row of nozzles between two colors = 8

$D_2$  = distance between two rows of the same color in dot-lines = 2

Both  $D_1$  and  $D_2$  will always be integral numbers of dot rows. We can now say that if the dot row of nozzles is row L, then row 1 of color C is dot-line:

15  $L - (C-1) D_1$

and row 2 of color C is dot-line:

$L - (C-1) D_1 - D_2$

The relationship between color planes for a given odd/even dot position in Table 1. for an example 6-color printhead. Note that if one of the 6 colors is fixative it

20 should be printed first.

**Table 1. Relationship between different rows of nozzles**

Color	Sense	dot line	when $D_2=2, D_1=8$
0 (fixative)	even nozzle	L	L
	odd nozzle	$L - D_2$	$L - 2$

1 (black)	even nozzle	$L - D_1$	$L - 8$
	odd nozzle	$L - D_1 - D_2$	$L - 10$
2 (yellow)	even nozzle	$L - 2D_1$	$L - 16$
	odd nozzle	$L - 2D_1 - D_2$	$L - 18$
3 (magenta)	even nozzle	$L - 3D_1$	$L - 24$
	odd nozzle	$L - 3D_1 - D_2$	$L - 26$
4 (cyan)	even nozzle	$L - 4D_1$	$L - 32$
	odd nozzle	$L - 4D_1 - D_2$	$L - 34$
5 (infrared)	even nozzle	$L - 5D_1$	$L - 40$
	odd nozzle	$L - 5D_1 - D_2$	$L - 42$

Each of the colored inks used in a printhead has different characteristics in terms of viscosity, heat profile etc. Firing pulses are therefore generated independently for each color.

- 5 In addition, although coated paper may be used for printing, fixative is required for high speed printing applications on plain paper. When fixative is used it should be printed before any of the other inks are printed to that dot position. In most cases, the fixative plane represents an OR of the data for that dot position, although it does depend on the ink characteristics. Printing fixative first also preconditions the paper
- 10 so that the subsequent drops will spread to the right size.

Figure 6 shows more detail of a single printhead chip (3) in the module array, considering only a single row of nozzles for a single color plane. Each of the printhead chips (3) can be configured to produce dots for multiple sets of lines. The

leftmost  $d$  nozzles ( $d$  depends on the angle that the modules is placed at) produce dots for line  $n$ , the next  $d$  nozzles produce dots for line  $n-1$ , and so on.

If a printhead chip (3) consists of 640 nozzles in a single row of odd or even nozzles (totalling 1280 nozzles of a single color) and the angle of printhead chips (3) placement produces a height difference of 64 lines (as shown in Figure 5), then  $d=10$ . This means that the module (2) prints 10 dots on each of 64 sets of lines. If the first dotline was line L, then the last dotline would be dotline L-63.

As can be seen by the placement of adjacent modules (2) in Figure 7, the corresponding row of nozzles in each modules produces dots for the same set of 64 lines, just horizontally shifted. The horizontal shift is an exact number of dots. Given  $S$  printhead chips (3), then a given print cycle produces  $dS$  dots on the same line. If  $S = 15$ , then  $dS = 150$ .

Although each 21mm printhead chip (3) prints 1600 dpi bi-level dots over a different part of page to produce the final image, there is some overlap between printhead chips (3), as shown in Figure 11. Given a particular overlap distance, each printhead chips (3) can be considered to have a lead-in area, a central area, and a lead-out area. The lead-out of one chip (3) corresponds to the lead-in of the next. The central area of a chip (3) is that area that has no overlap at all. Figure 11 illustrates the three areas of a chip (3) by showing two overlapping chips in terms of aligned print-lines. Note that the lead-out area of chip  $S$  corresponds to the lead-in area of chip  $S+1$ .

When producing data for the printhead, care must be taken when placing dot data into nozzles corresponding to the overlap region. If both nozzles fire the same data, then twice as much ink will be placed onto the pages in overlap areas. Instead, the dot data generator should start placing data into chip  $S$  at the start of the chip overlap region while removing the data from the corresponding nozzles in chip  $S+1$ , and ramp stochastically across the overlap area so that by the end of the overlap area, the data is all allocated to nozzles in chip  $S+1$ .

In addition, a number of considerations must be made when wiring up a printhead. As the width of the printhead increases, the number of modules (2) increases, and the number of connections also increases. Each chip (3) has its own  $Dn$  connections

(C of them), as well as *SrClk* and other connections for loading and printing.

When the number of chips is small it is reasonable to load all the chips (3) simultaneously by using a common *SrClk* line and placing *C* bits of data on each of the *Dn* inputs for the chips. In a 4-chip 4 color printer, the total number of bits to transfer to the printhead in a single *SrClk* pulse is 16. However for a Netpage (see cross references) enabled (C=6) 12-inch printer, S=15, and it is unreasonable to have 90 data lines running from the print data generator to the printhead.

Instead, it is convenient to group a number of chip (3) together for loading purposes. Each group of chips (3) is small enough to be loaded simultaneously, and share a *SrClk*. For example, a 12-inch printhead can have 2 chip groups, each chip group containing 8 chips (3). 48 *Dn* lines can be shared for both groups, with 2 *SrClk* lines, one per chip group.

As the number of chip groups increases, the time taken to load the printhead increases. When there is only one group, 1280 load pulses are required (each pulse transfers *C* data bits). When there are *G* groups, 1280*G* load pulses are required. The connection between the data generator and the printhead is at most 80 MHz.

If *G* is the number of chip groups, and *L* is the largest number of chips in a group, the printhead requires *LC Dn* lines and *G SrClk* lines. Regardless of *G*, only a single *LSyncL* line is required - it can be shared across all chips.

Since *L* chips in each chip group are loaded with a single *SrClk* pulse, any printing process must produce the data in the correct sequence for the printhead. As an example, when *G*=2 and *L*=4, the first *SrClk0* pulse will transfer the *Dn* bits for the next print cycle's dot 0, 1280, 2560 and 3840. The first *SrClk1* pulse will transfer the *Dn* bits for the next print cycle's dot 5120, 6400, 7680, and 8960. The second *SrClk0* pulse will transfer the *Dn* bits for the next print cycle's dot 1, 1281, 2561, and 3841. The second *SrClk1* pulse will transfer the *Dn* bits for the next print cycle's dot 5121, 6401, 7681 and 8961.

After 1280*G SrClk* pulses (1280 to each of *SrClk0* and *SrClk1*), the entire line has been loaded into the printhead, and the common *LSyncL* pulse can be given at

the appropriate time.

As described above, the nozzles for a given chip (3) do not all print out on the same line. Within each color there are  $d$  nozzles on a given line, with the odd and even nozzles of the group separated by  $D_2$  dot-lines. There are  $D_1$  lines between corresponding nozzles of different colors ( $D_1$  and  $D_2$  parameters are further described in Section and Section ). The line differences must be taken into account when loading data into the printhead. Considering only a single chip group, Table 2. shows the dots transferred to chip  $n$  of a printhead during the a number of pulses of the shared  $SrClk$ .

Table 2. Order of dots transferred to chip  $S$  in a modular printhead

pulse	Dot	color0 line	color1 line	colorC line
0	$1280S^1$	N	$N-D_1^2$	$N-CD_1$
1	$1280S+1$	$N-D_2^3$	$N-D_1-D_2$	$N-CD_1-D_2$
2	$1280S+2$	N	$N-D_1$	$N-CD_1$
3	$1280S+3$	$N-D_2$	$N-D_1-D_2$	$N-CD_1-D_2$
$2d^4$	$1280S+2d$	$N-1$	$N-D_1-1$	$N-CD_1-1$
$2d+1$	$1280S+2d+$	$N-D_2-1$	$N-D_1-D_2-1$	$N-CD_1-D_2-1$

And so on for all 1280  $SrClk$  pulses to the particular chip group.

With regards to printing, we print 10C nozzles from each chip in the lowest speed printing mode, and 80C nozzles from each chip in the highest speed printing mode.

<sup>1</sup> S = chip number

<sup>2</sup>  $D_1$  = number of lines between the nozzles of one color and the next (likely = 7-10)

<sup>3</sup>  $D_2$  = number of lines between two rows of nozzles of the same color (likely = 2)

<sup>4</sup>  $d$  = number of nozzles printed on the same line by a given chip

While it is certainly possible to wire up chips in any way, this document only considers the situation where all chips fire simultaneously. This is because the low-speed printing mode allows low-power printing for small printheads (e.g. 2-inch and 4-inch), and the controller chip design assumes there is sufficient power available for the large print sizes (such as 8-18 inches). It is a simple matter to alter the connections in the printhead to allow grouping of firing should a particular application require it.

When all chips are fired at the same time 10CS nozzles are fired in the low-speed printing mode and 80CS nozzles are fired in the high-speed printing mode.

A chip produces an analog line of feedback used to adjust the profile of the firing pulses. Since multiple chips are collected together into a printhead, it is effective to share the feedback lines as a tri-state bus, with only one of the chips placing the feedback information on the feedback lines at a time.

The printhead is constructed from a number of chips as described in the previous sections. It assumes that for data loading purposes, the chips have been grouped into  $G$  chip groups, with  $L$  chips in the largest chip group. It assumes there are  $C$  colors in the printhead. It assumes that the firing mechanism for the printhead is that all chips fire simultaneously, and only one chip at a time places feedback information on a common tri-state bus. Assuming all these things, Table 3 lists the external connections that are available from a printhead:

**Table 3. Printhead connections**

name	#pins	description
Dn	CL	Inputs to C shift registers of chips 0 to L-1
SrClk	G	A pulse on SrClk[N] (ShiftRegisterClock N) loads the current values from Dn lines into the L chips in chip group N.
LSyncL	1	A pulse on LSyncL performs the parallel transfer from the shift registers to the internal

		NozzleEnable bits and starts the printing of a line for all chips.
hclk	1	Phase Locked Loop clock for generation of timing signals in printhead
Reset	1	Control reset
SCL	1	serial clock for control
SDA	1	serial data for control
Sense	1	Analog sense output
Gnd	1	Analog sense ground
V-	Many, depending on the number of colors	Negative actuator supply
V+		Positive actuator supply
V <sub>ss</sub>		Negative logic supply
V <sub>dd</sub>		Positive logic supply

Referring to Figures 8 to 18, the modular printhead has a metal chassis (1) which is fixedly mounted within a digital inkjet printer (not shown). Snap-locked to the metal chassis (1) are a plurality of replaceable printhead modules (2). The modules (2) are sealed units with four separate ink channels that feed a printhead chip (3). As best seen in figure 7, each printhead module (2) is plugged into a reservoir moulding (4) that supplies ink to the integrally moulded funnels (5).

The ink reservoir (4) may itself be a modular component so the entire modular printhead is not necessarily limited to the width of a page but may extend to any arbitrarily chosen width.

Referring to Figures 15 to 18, the printhead modules (2) each comprise a printhead chip (3) bonded to a TAB film (6) accommodated and supported by a micro moulding (7). This is, in turn, adapted to mate with a cover moulding (8). The printhead chip (3)



is a MEMS (micro electro mechanical System) device. Typically, MEMJET™ chips print cyan, magenta, yellow and black (CMYK) ink. This provides color printing at an image resolution of 1600 dots per inch (DPI) which is the accepted standard for photographic image quality.

5 If there is a defect in the chip it usually appears as a line or void in the printing. If the printhead were to be formed from a single chip then the entire printhead would need replacement. By modularising the printheads there is less probability that any particular printhead module will be defective. It will be appreciated that the replacement of single printhead modules and the greater utilisation of silicon wafers provide a significant  
10 saving in production and operating costs.

The TAB film (6) has a slot to accommodate the MEMJET™ chip (3) and gold plated contact pads (9) that connect with the flex PCB (flexible printed circuit board) (10) and busbar (11) to get data and power respectively to the printhead. The busbars (11) are thin fingers of metal strip separated by an insulating strip. The busbar sub-  
15 assembly (11) is mounted on the underside of the side wall ink reservoir (4).

The flex PCB (10) is mounted to the angled side wall of the reservoir (4). It wraps beneath the side wall of the reservoir (4) and up the external surface carrying data to the MEMJET™ modules (2) via a 62 pin header (12). Side wall of the ink reservoir (4) is angled to correspond with the side of the cover moulding (8) so that when the printhead  
20 module (2) is snap-locked in place, the contacts (9) wipe against the corresponding contacts on the flex PCB to promote a reliable electrical connection. The angle also assists the easy removal of the modules (2). The flex PCB (11) is "sprung" by the action of a foam backing (13) mounted between the wall and the underside of the contact area.

25 Rib details on the underside of the micro moulding (7) provide support for the TAB film (6) when they are bonded together. The TAB film (6) forms the underside wall of the printhead module (2) as there is enough structural integrity between the pitch of the ribs to support a flexible film. The edges of the TAB film (6) are sealed on the underside of the walls of the cover moulding (8). The chip (3) is bonded onto 100  
30 micron wide ribs that run the length of the micro moulding (7) providing the final ink feed into the MEMJET™ print nozzles.

The design of the micro moulding (7) allows for a physical overlap of the MEMJET™ chips (3) when the modules (2) are mounted adjacent one another. Because the printhead modules (2) form a continuous strip with a generous tolerance, they can be electronically adjusted to produce a continuous print pattern, rather than relying on very close tolerance mouldings and exotic materials to perform the same function. According to this embodiment, the printing chips (3) are 21 mm long but are angled such that they provide a printing width of 20.33 mm.

The micro moulding (7) fits inside the cover moulding (8) where it bonds onto a set of vertically extending ribs. The cover moulding (8) is a two shot precision injection moulding that combines an injected hard plastic body with soft elastomeric sealing collars at the inlet to each ink chamber defined within the module.

Four snap-lock barbs (15) mate with the outer surface of the ink reservoir (4) which acts as an extension of metal chassis (1). The ink funnels (5) sealingly engage with the elastomeric collars (14).

The modular design conveniently allows the MEMJET™ printhead modules (2) to be removably snap-locked onto the ink reservoir (4). Accurate alignment of the MEMJET™ chip (3) with respect to the metal chassis is not necessary as a complete modular printhead will undergo digital adjustment of each chip (3) during final quality assurance testing.

The TAB film (6) for each module (2) interfaces with the flex PCB (11) and the busbars (11) as it is clipped onto the ink reservoir (4). To disengage a MEMJET™ printhead module (2) the snap-lock barbs (15) may be configured for release upon the application of sufficient force by the user. Alternatively, the snap-lock barbs (15) can be configured for a more positive engagement with the ink reservoir (4) such that a customised tool (not shown) is required for disengagement of the module.

The invention has been described herein by way of example only and skilled workers in this field will readily recognise many variations and modifications which do not depart from the spirit and scope of the broad inventive concept.

## CLAIMS:-

1. A modular printhead for a inkjet printer, the modular printhead including:  
a support frame;  
a plurality of printhead modules mounted to the support frame, each module  
5 having an elongate array of ink nozzles extending substantially linearly across the width  
of the module such that there is overlap between the elongate arrays of adjacent modules  
with respect to the direction of paper movement; wherein,  
the modules are arranged such that a first side of each of the nozzle arrays faces  
toward a first side of the support frame; such that,  
10 the respective first sides of predominantly all of the nozzle arrays have at most  
one end portion obscured from the first side of the support frame by the nozzle array of  
an adjacent module.
2. A modular printhead according to claim 1 wherein the respective first sides of each  
of the nozzle arrays have at most one end portion obscured from the first side of the  
15 support frame by the nozzle array of an adjacent module.
3. A modular printhead according to claim 2 wherein the modules are mounted to the  
support frame along a substantially straight mounting line such that each of the elongate  
arrays extends in a direction inclined to the mounting line of the modules.
4. A modular printhead according to claim 3 wherein the mounting line is normal to  
20 the paper direction.
5. A modular printhead according to claim 4 wherein the printhead is digitally  
controlled such that print data sent to the overlapping portions of adjacent modules is  
shared between the ink nozzles of the adjacent modules to avoid double printing of the  
same data.
- 25 6. A modular printhead according to claim 5 wherein the digital controller starts to  
place print data with the nozzles in an adjacent module at the one edge of the  
overlapping portion, and ramps up the data directed to the nozzles of the adjacent  
module stochastically until all the print data is directed to the adjacent module at the  
opposing edge of the overlapping portion.
- 30 7. A modular printhead according to claim 1 wherein the printhead is a pagewidth  
printhead.

8. A modular printhead according to claim 1 wherein the printhead modules are adapted to be individually removed and replaced.
9. A modular printhead according to claim 1 wherein the printhead modules are adapted for snap-locking engagement with the support frame.

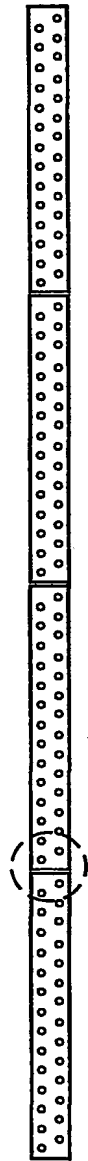


FIG. 1

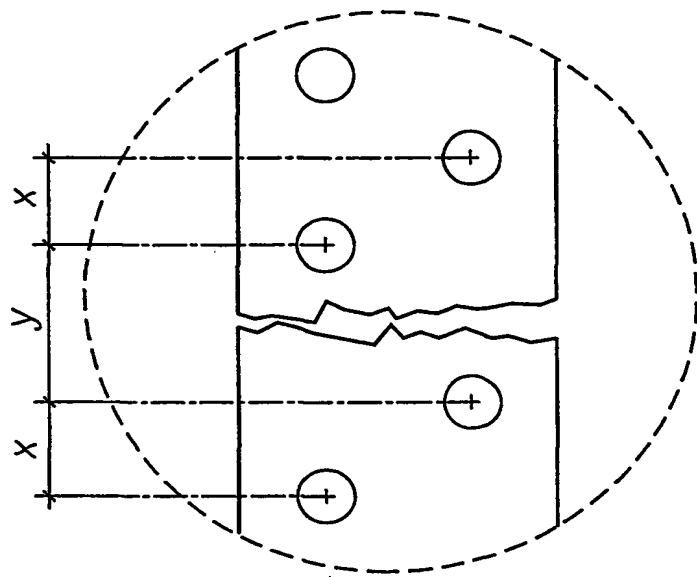


FIG. 2

2/12

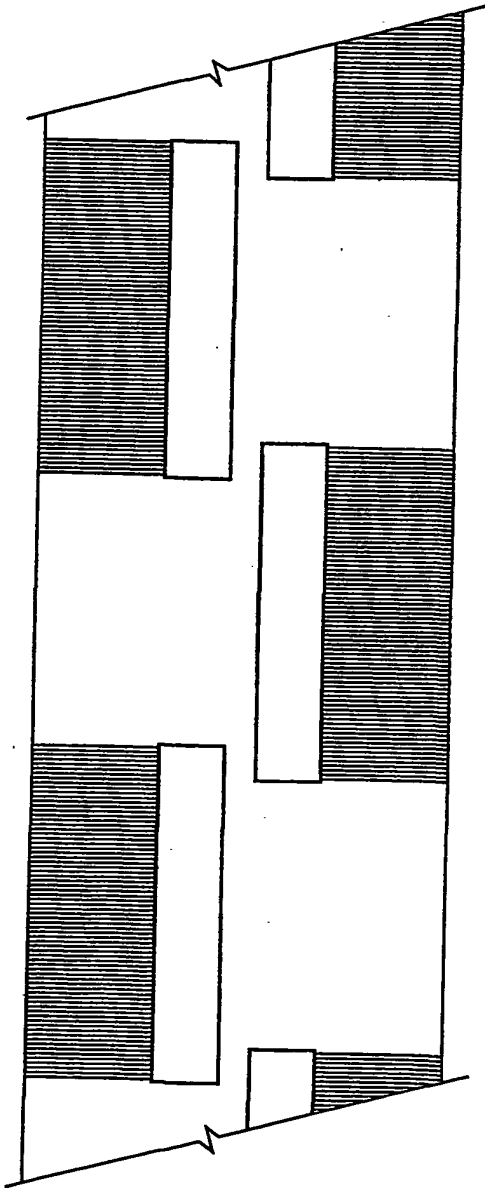


FIG. 3

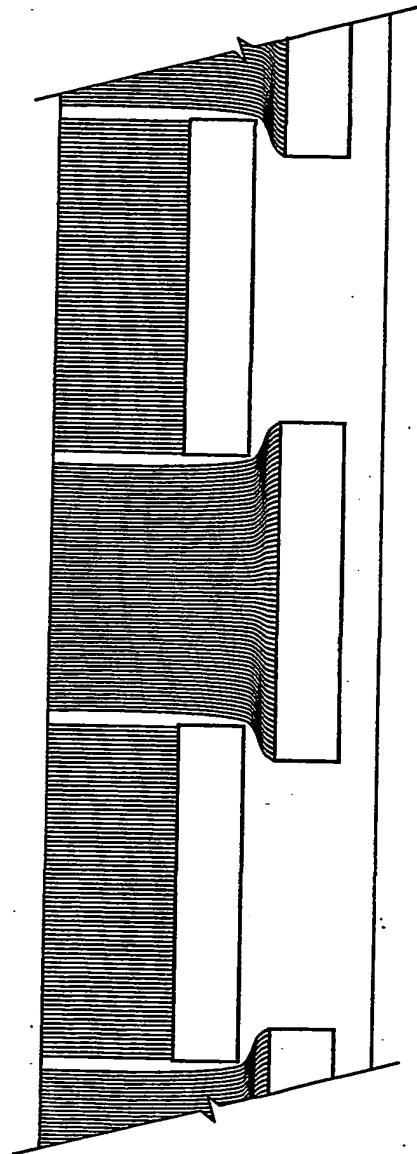


FIG. 4

3/12

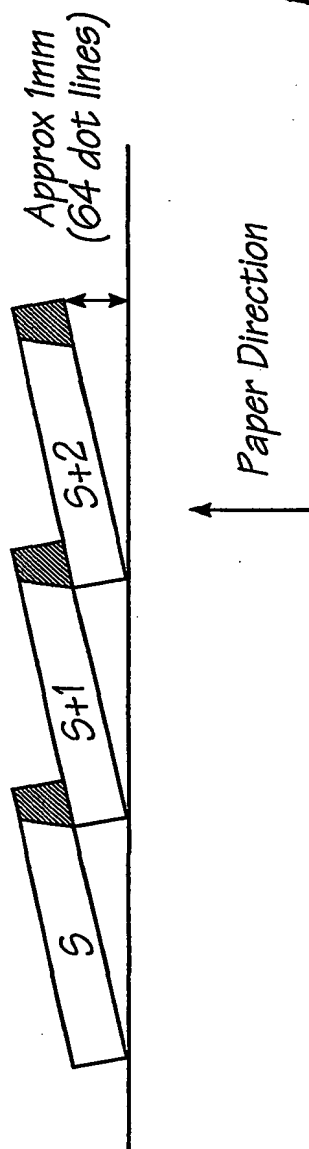


FIG. 5a

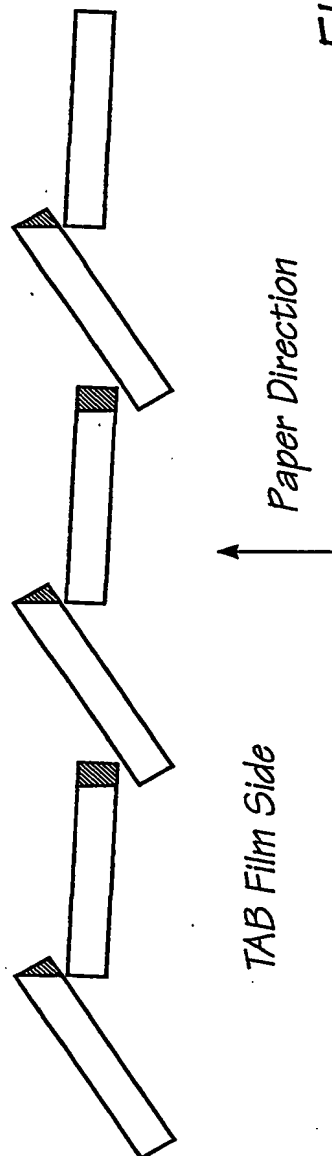


FIG. 5b

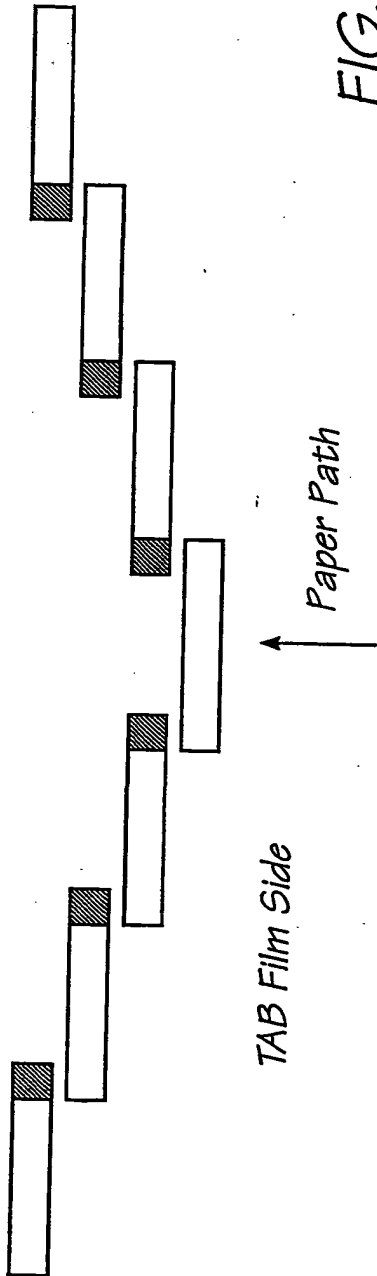


FIG. 5c

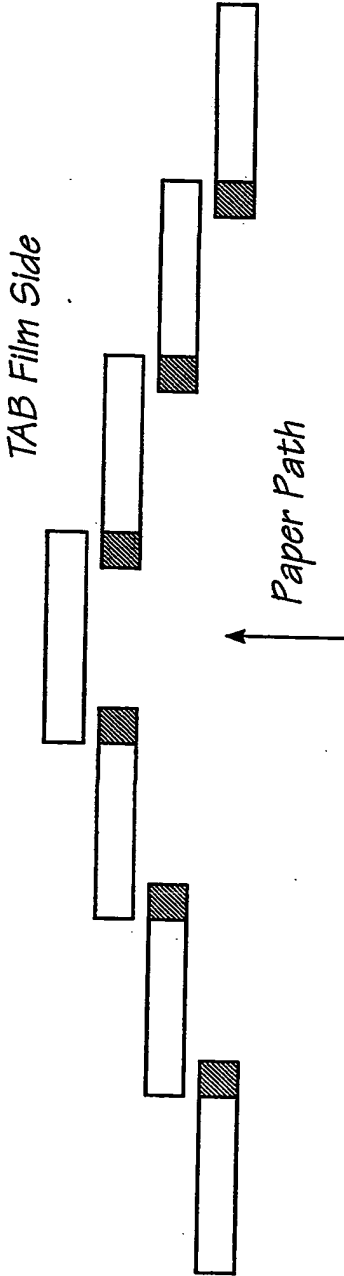


FIG. 5d



5/12

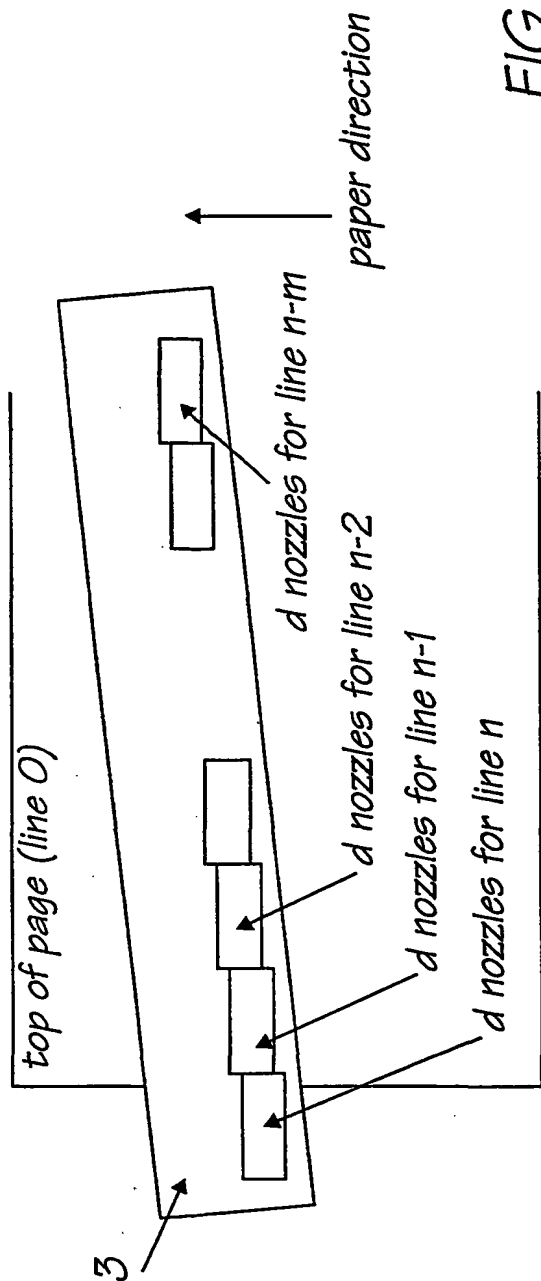


FIG. 6

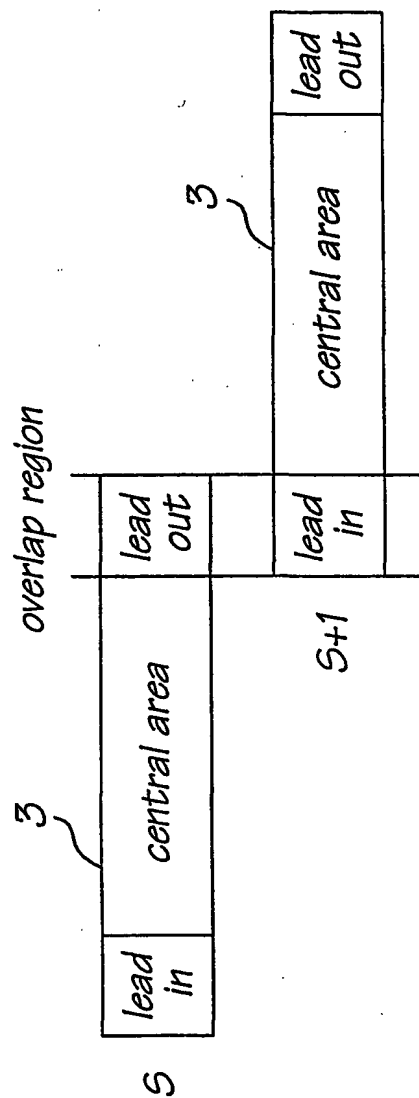


FIG. 7

6/12

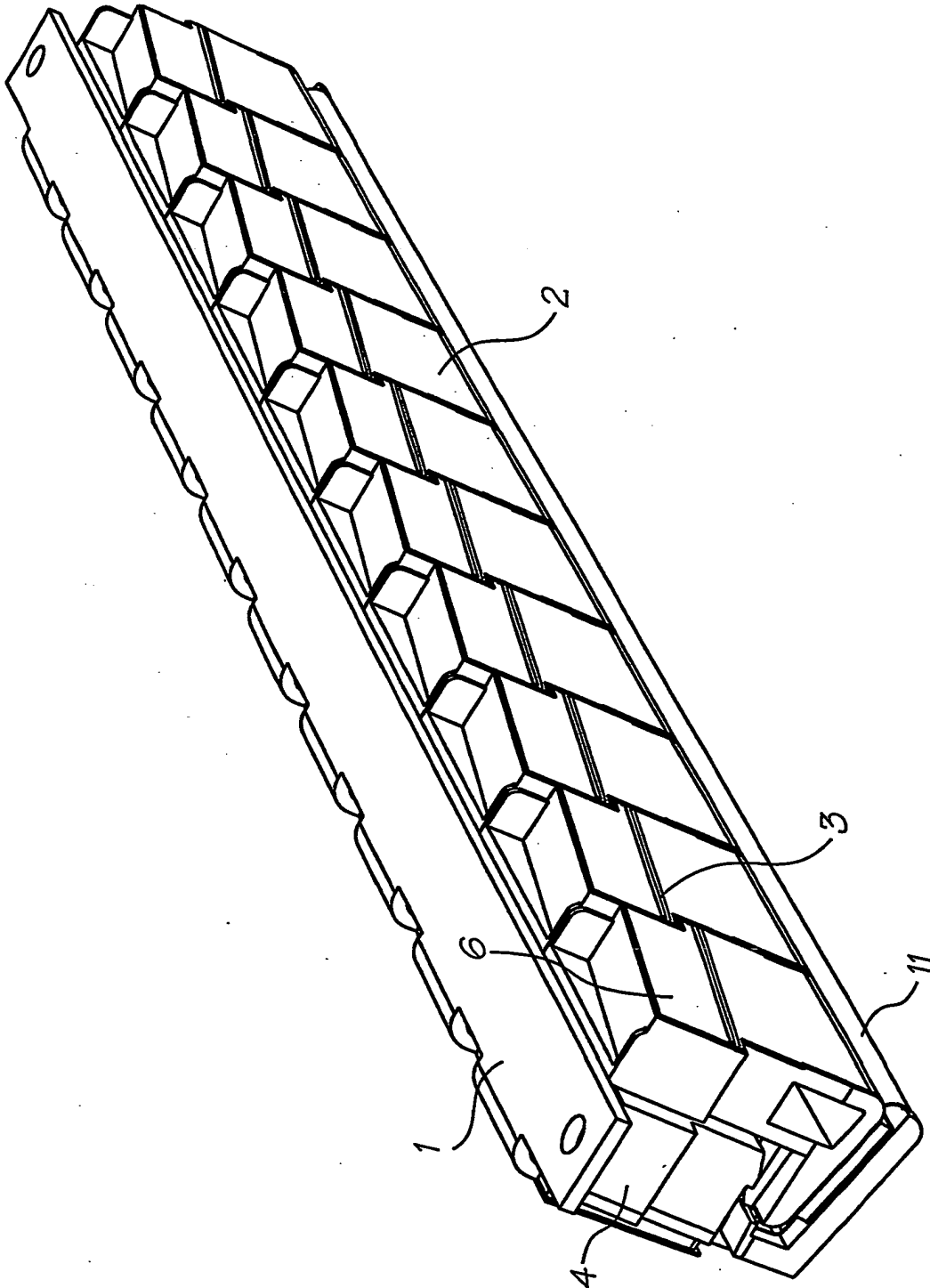


FIG. 8

7/12

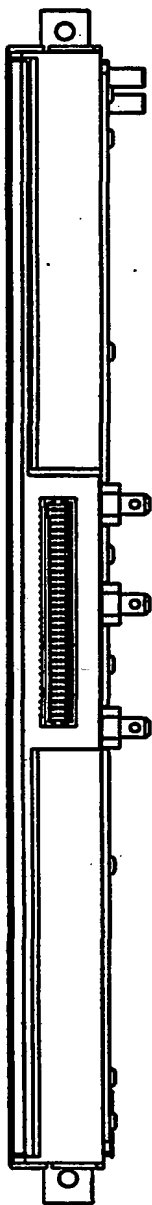


FIG. 9

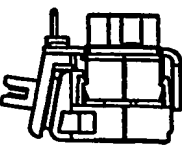


FIG. 13

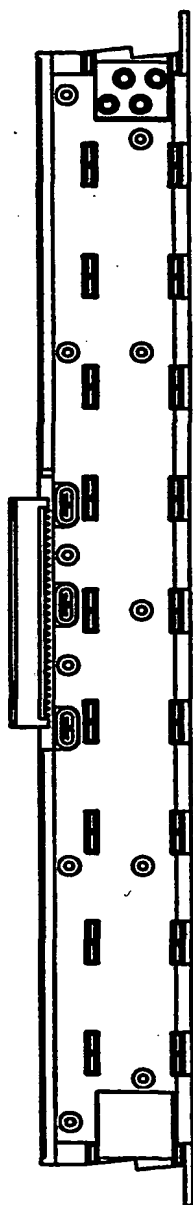


FIG. 10

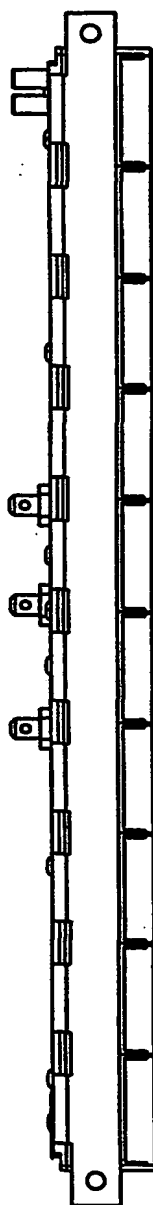


FIG. 11



FIG. 12

8/12

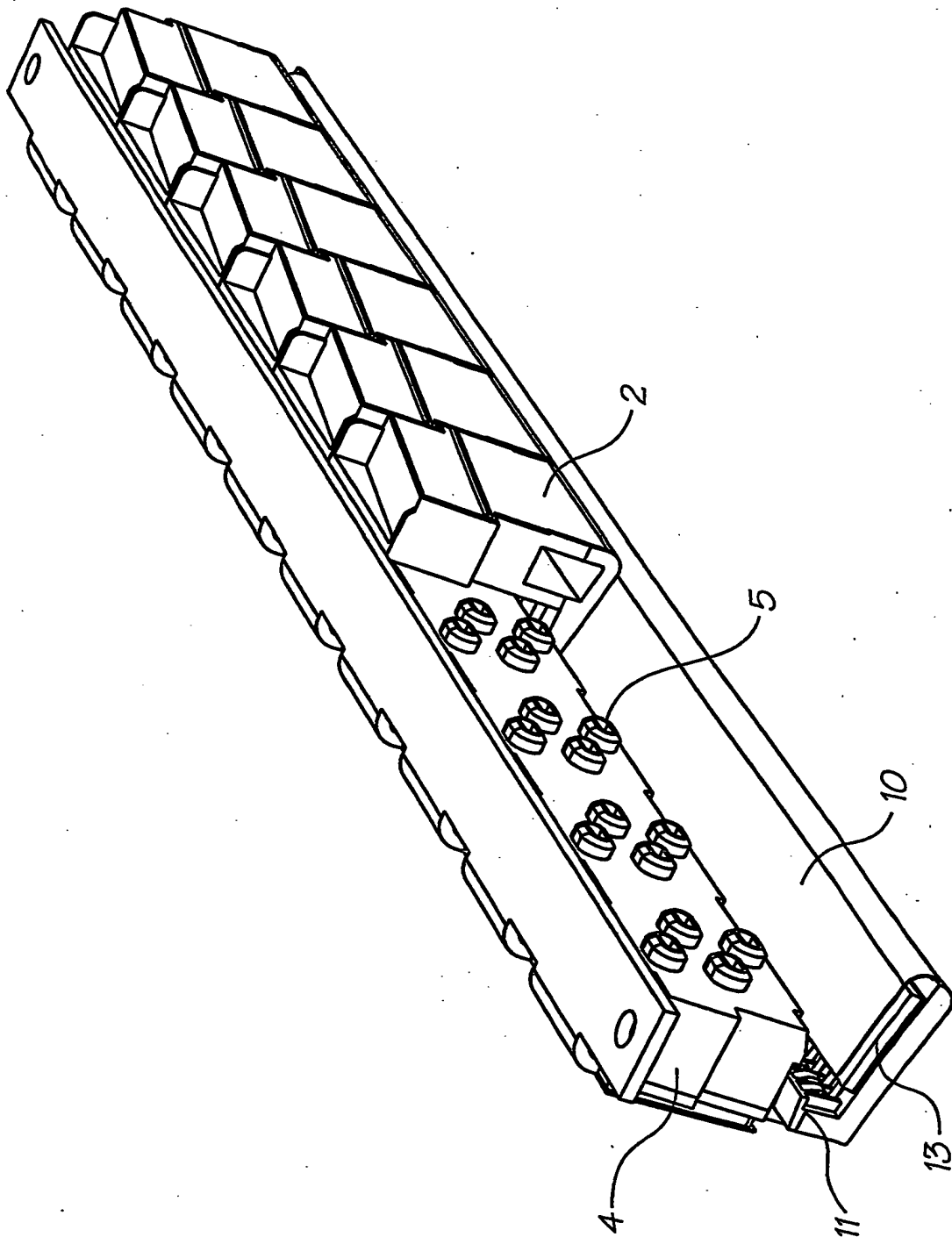


FIG. 14

9/12

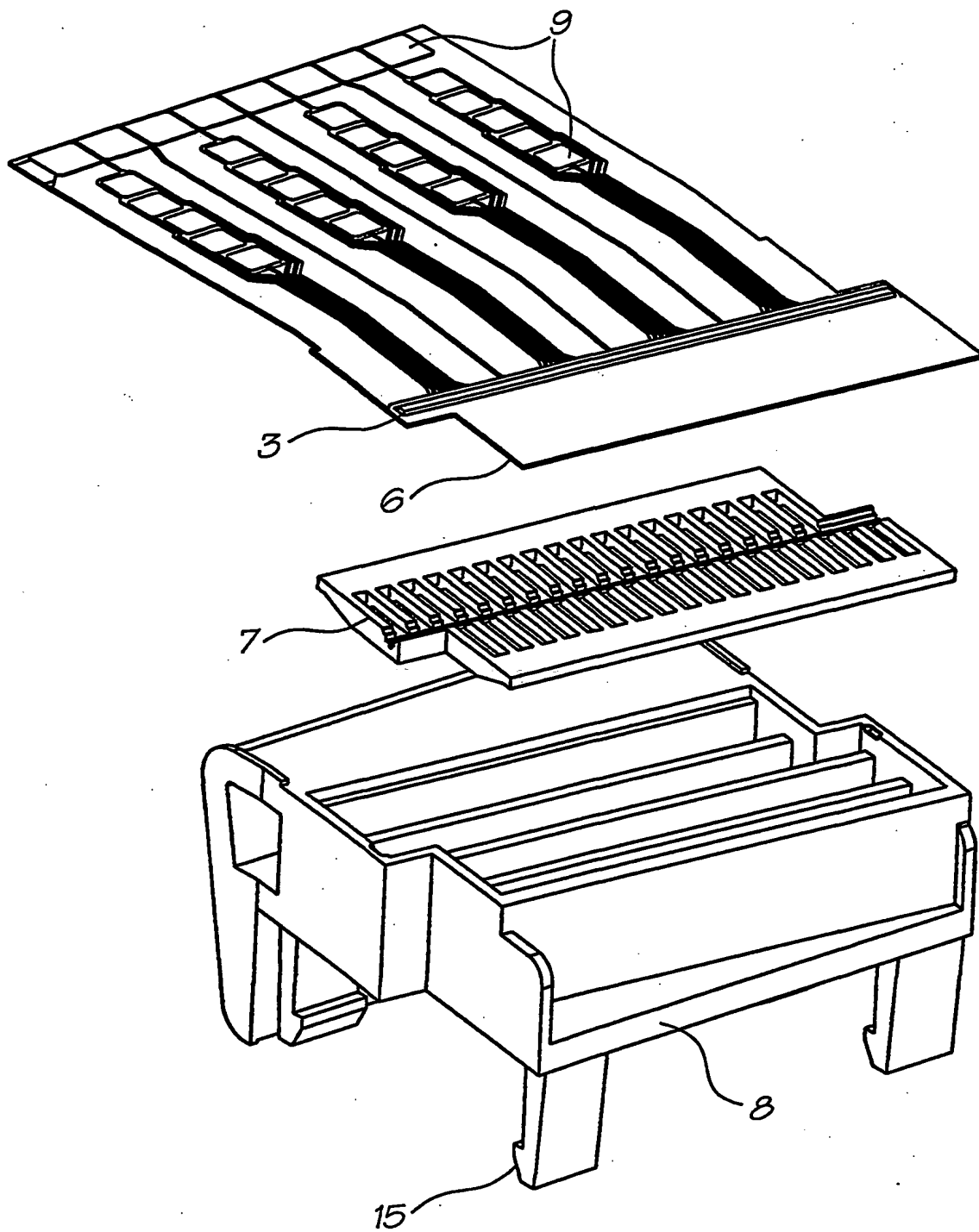


FIG. 15

10/12

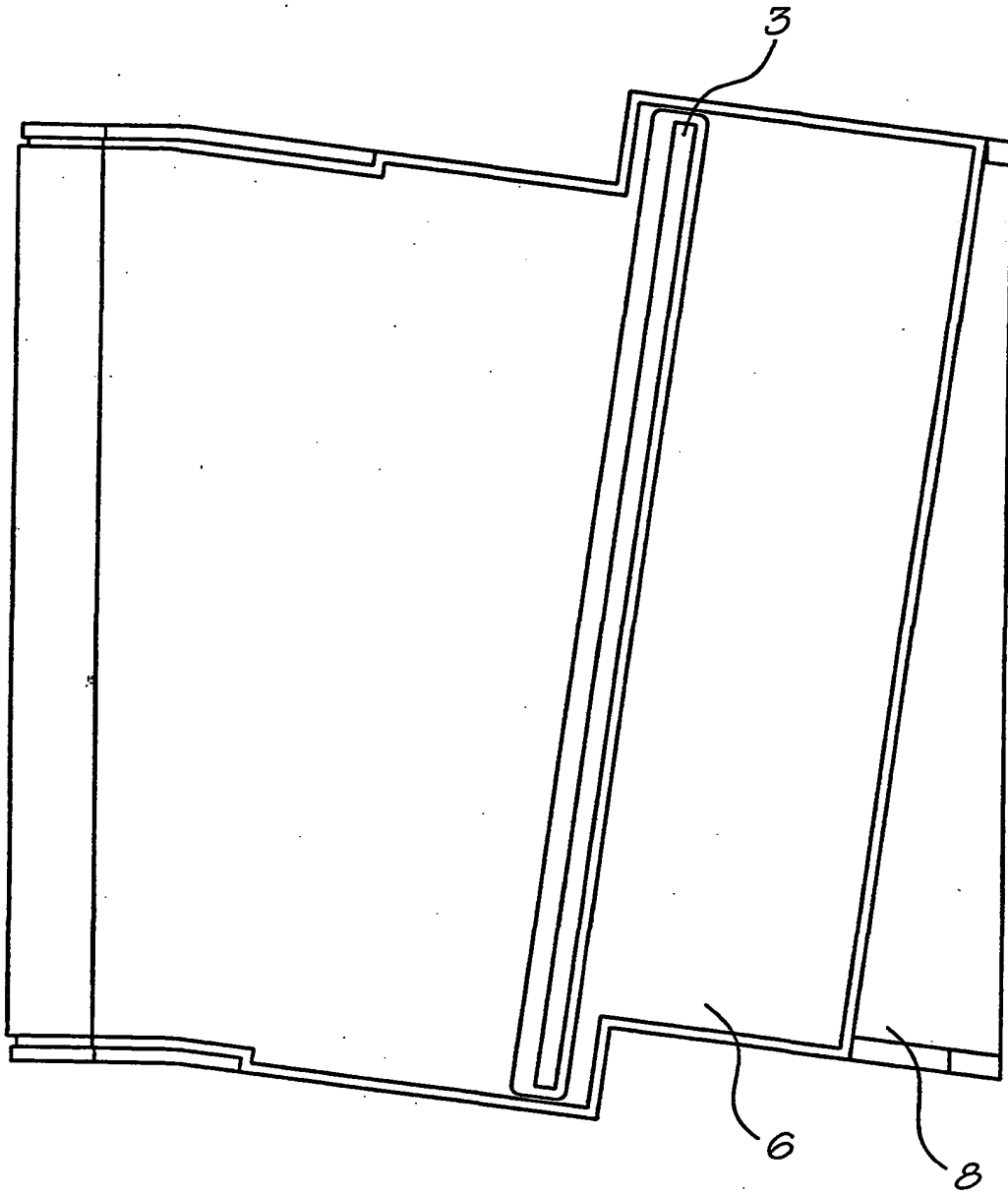


FIG. 16

11/12

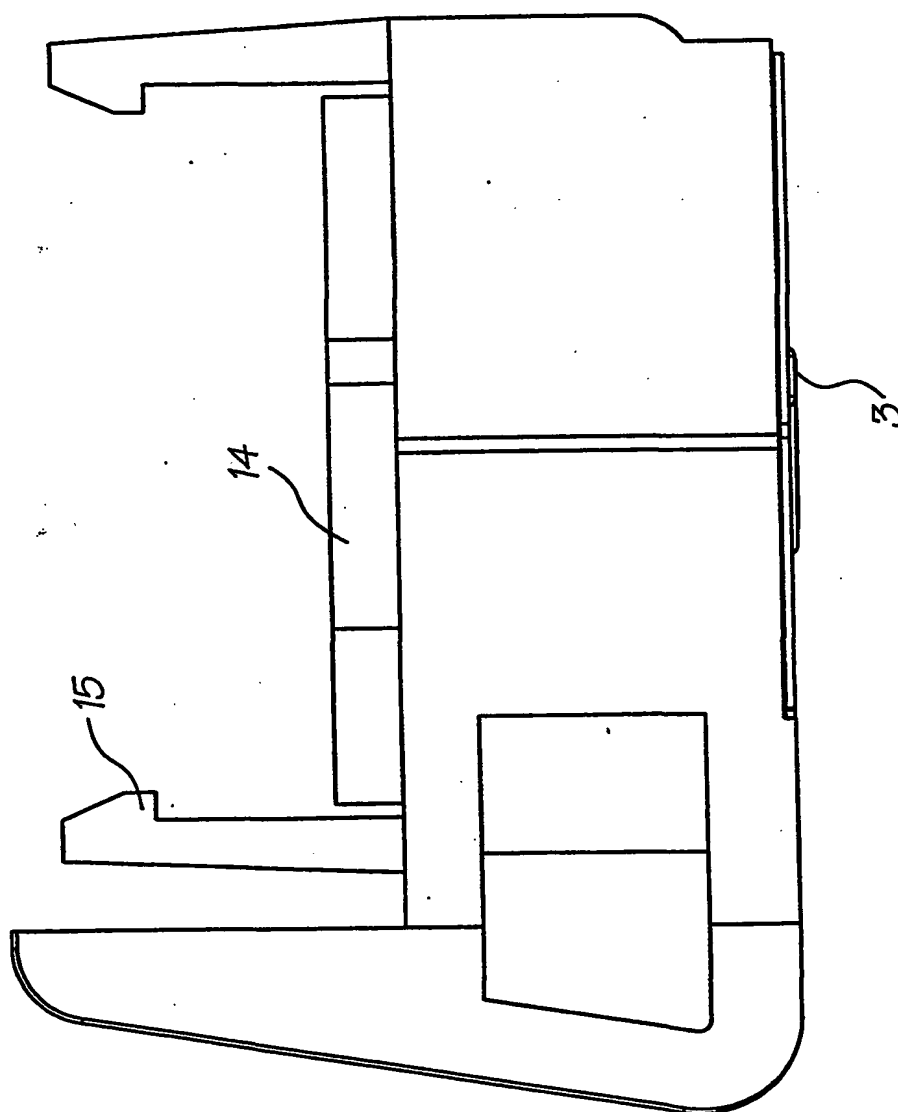


FIG. 17

12/12

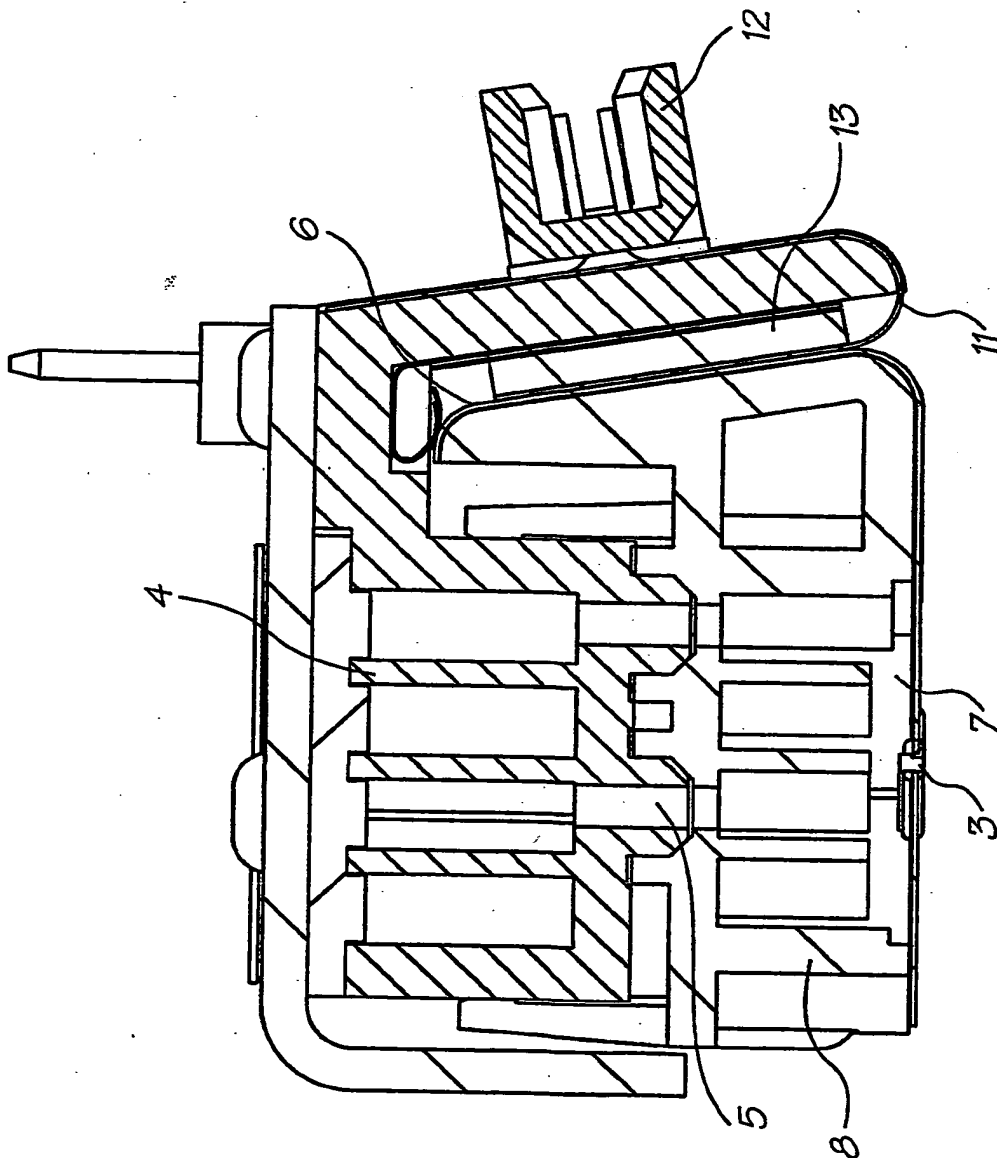


FIG. 18



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/AU01/00216

**A. CLASSIFICATION OF SUBJECT MATTER**Int. Cl. <sup>7</sup>: B41J 2/145, 2/155

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC: B41J 2/-, 29/-

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

DWPI: &amp; keywords: INKJET, PRINthead, PAGEWIDTH, OVERLAP AND SIMILAR TERMS

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 034060 A1 (THE MEAD CORPORATION) 19 August 1981 Whole document - figures 1 and 2	1, 2, 7-9
P, X	WO 00/64680 A (SILVERBROOK RESEARCH PTY LTD) 2 November 2000 Whole document - figure 5	1-9

☐ Further documents are listed in the continuation of Box C
 ☒ See patent family annex

* Special categories of cited documents:	
"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E" earlier application or patent but published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

14 May 2001

Date of mailing of the international search report

6 June 2001

Name and mailing address of the ISA/AU

 AUSTRALIAN PATENT OFFICE  
 PO BOX 200, WODEN ACT 2606, AUSTRALIA  
 E-mail address: pct@ipaustalia.gov.au  
 Facsimile No. (02) 6285 3929

Authorized officer

ADRIANO GIACOBETTI

Telephone No : (02) 6283 2579

**INTERNATIONAL SEARCH REPORT**  
Information on patent family members

International application No.  
**PCT/AU01/00216**

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member	
EP	34060	JP	56-127460
WO	00/64680	WO	00/40914
END OF ANNEX			

**This Page is Inserted by IFW Indexing and Scanning  
Operations and is not part of the Official Record**

**BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ BLACK BORDERS
- ☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☐ FADED TEXT OR DRAWING
- ☒ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☐ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☐ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: \_\_\_\_\_

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.**

**THIS PAGE BLANK (USPTO)**